PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-260596

(43)Date of publication of application : 24.09.1999

(51)Int.Cl. H05H 1/46
C23C 16/50
C23F 4/00
H01L 21/205
H01L 21/3065
H01L 21/31

(21)Application number : 10-064975

(22)Date of filing : 16.03.1998

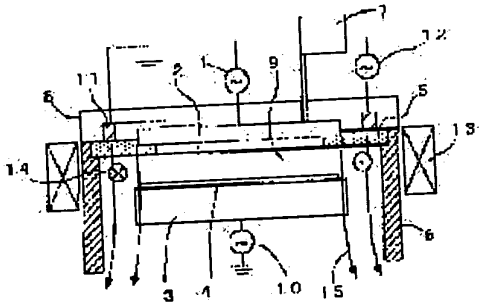
(71)Applicant : HITACHI LTD

(72)Inventor : OTSUBO TORU
TANAKA JUNICHI
SASAKI ICHIRO
MASUDA TOSHIO
KAJI TETSUNORI
WATANABE KATSUYA

(54) PLASMA PROCESSING DEVICE AND PLASMA PROCESSING METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To control the constituents and capacity of activating seeds and thereby carry out highly selective etching, and high-precision and high-speed etching by controlling electron energy and electron density in plasma by means of electromagnetic waves.



SOLUTION: A process gas in a processing chamber 9 is transformed to plasma by the use of a capacitive coupling discharge means by supplying power from a power supply 1 to a parallel, flat electrode 2, and thereby various activating seeds are produced, and an electric field 14 is induced near a side wall part 6 by an electromagnetic wave radiating antenna 11, and the condition of the wall surface of the side wall part 6 is controlled by adjusting a power supply 12. The diffused plasma also infiltrate into the gaps of

parallel, flat electrode plates 2, 3, so that radical composition can be controlled. In addition, by generating magnetic lines of force 15 by the use of a magnetic field generating means 13 and thereby developing electron cyclotron resonance by the electric field 14 of the antenna 11 and the magnetic lines of force 15, plasma is effectively generated, and thus, the performance of minute processing can be optimized by regulating the intensity of the magnetic field 15 and thereby adjusting the radical ingredient ratio.

LEGAL STATUS

[Date of request for examination]	19.09.2002
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Plasma treatment equipment with which the aforementioned plasma generating means is characterized by the bird clapper in the plasma treatment equipment which has a plasma treatment gas supply means, a plasma treatment indoor exhaust air means, a plasma generating means, and the means that exposes and carries out plasma treatment of the processing substrate to the generated plasma from a capacity-coupling form electric discharge means and an electro-magnetic-radiation means.
[Claim 2] Plasma treatment equipment characterized by considering as the composition which connected the electro-magnetic-radiation means by the aforementioned capacity-coupling electric discharge means and the guidance method antenna in series in plasma treatment equipment according to claim 1.
[Claim 3] plasma treatment equipment according to claim 1 -- setting -- the conductor of plurality [means / electro-magnetic-radiation / aforementioned] -- the plasma treatment equipment characterized by generating RF electric field and emitting an electromagnetic wave among parts
[Claim 4] Plasma treatment equipment with which the aforementioned electro-magnetic-radiation means is characterized by dividing into plurality the electrode of a capacity-coupling electric discharge means to impress high-frequency voltage, establishing the high-frequency-voltage phase impressed to each inter-electrode ones, and a means to change a high-frequency-voltage amplitude, making each aforementioned inter-electrode one generate RF electric field, and emitting an electromagnetic wave by this RF electric field in plasma treatment equipment according to claim 1.
[Claim 5] Plasma treatment equipment with which the aforementioned plasma generating means is characterized by the bird clapper in the plasma treatment equipment which has a plasma treatment gas supply means, a plasma treatment indoor exhaust air means, a plasma generating means, and the means that exposes and carries out plasma treatment of the processing substrate to the generated plasma from a capacity-coupling form electric discharge means, an electro-magnetic-radiation means, and magnetic field means forming.
[Claim 6] Plasma treatment equipment characterized by the aforementioned electro-magnetic-radiation means being the antenna of a guidance method in plasma treatment equipment according to claim 5.
[Claim 7] Plasma treatment equipment characterized by considering the aforementioned capacity-coupling electric discharge means and a guidance method antenna means as the composition connected in series in plasma treatment equipment according to claim 6.
[Claim 8] plasma treatment equipment according to claim 5 -- setting -- the conductor of plurality [means / electro-magnetic-radiation / aforementioned] -- the plasma treatment equipment characterized by generating RF electric field and emitting an electromagnetic wave among parts
[Claim 9] the conductor from which the electrode and the aforementioned electrode of a capacity-coupling electric discharge means by which the aforementioned electro-magnetic-radiation means impresses high-frequency voltage were insulated in plasma treatment equipment according to claim 5 -- the plasma treatment equipment characterized by establishing the means which RF electric field generate between the composition members which are parts, and emitting an electromagnetic wave to it by this RF electric field

[Claim 10] Plasma treatment equipment with which the aforementioned electro-magnetic-radiation means is characterized by dividing into plurality the electrode of a capacity-coupling electric discharge means to impress high-frequency voltage, establishing the high-frequency-voltage phase impressed to each inter-electrode ones, and a means to change a high-frequency-voltage amplitude, making each aforementioned inter-electrode one generate RF electric field, and emitting an electromagnetic wave by this RF electric field in plasma treatment equipment according to claim 5.
[Claim 11] Plasma treatment equipment characterized by forming so that a means to form the aforementioned magnetic field may become a perpendicular mostly in plasma treatment equipment according to claim 5 to the electric field of the electromagnetic wave emitted by the electro-magnetic-radiation means.
[Claim 12] the plasma treatment equipment which has a plasma treatment gas supply means,.a plasma treatment indoor exhaust air means, a plasma generating means, and the means that exposes and carries out plasma treatment of the processing substrate to the generated plasma -- setting -- the conductor of plurality [means / plasma generating / aforementioned] -- the plasma treatment equipment characterized by generating RF electric field, emitting an electromagnetic wave among parts, and generating plasma
[Claim 13] Plasma treatment gas supply means. A plasma treatment indoor exhaust air means, a plasma generating means, and the means that exposes and carries out plasma treatment of the processing substrate to the generated plasma. plasma treatment equipment equipped with the above -- it is -- the conductor of plurality [means / plasma generating / aforementioned] -- RF electric field are generated among parts and it is characterized by the bird clapper from a means to emit an electromagnetic wave, the electromagnetic wave emitted by the aforementioned electro-magnetic-radiation means, and a magnetic field generating means to generate the magnetic field of the conditions which generate a electron cyclotron resonance
[Claim 14] Plasma treatment gas supply means. Plasma treatment indoor exhaust air means. Plasma generating means. The means which exposes and carries out plasma treatment of the processing substrate to the generated plasma in the plasma treatment interior of a room. It is plasma treatment equipment equipped with the above, and is characterized by constituting from either a field which has a means to accelerate the ion in which the internal surface of the aforementioned plasma treatment room carries out incidence from plasma, or a field which has the means which maintains internal-surface temperature at the set-up temperature of 200 degrees C or less.
[Claim 15] Plasma treatment gas supply means. Plasma treatment indoor exhaust air means. Plasma generating means. The means which exposes and carries out plasma treatment of the processing substrate to the generated plasma in the plasma treatment interior of a room. It is plasma treatment equipment equipped with the above, and while accelerating the ion in which the internal surface of the aforementioned plasma treatment room carries out incidence from plasma, it is characterized by constituting from either a field which has a means to control the temperature of the front face, or a field which has the means which maintains internal-surface temperature at the set-up temperature of 200 degrees C or less.
[Claim 16] The plasma treatment method characterized by carrying out plasma treatment, emitting the electromagnetic wave generated by RF electric field into the aforementioned plasma while generating plasma by capacity coupling in the plasma treatment interior of a room.
[Claim 17] The plasma treatment method characterized by controlling and carrying out plasma treatment of the homogeneity of plasma treatment by preparing two or more portions which emit into plasma the electromagnetic wave generated by the aforementioned RF electric field in the plasma treatment method given in claim 16 term, and controlling the radiation electromagnetic wave power from the aforementioned electro-magnetic-radiation part.
[Claim 18] The plasma treatment method characterized by emitting the electromagnetic wave generated by RF electric field into the aforementioned plasma, and carrying out plasma treatment of the magnetic field perpendicularly with generating mostly to the electric field of the aforementioned electromagnetic wave while generating plasma by capacity coupling in the plasma treatment interior of a room.

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is explanatory drawing showing the plasma treatment room composition of the 1st example by this invention.
[Drawing 2] It is explanatory drawing showing the example of others of the electrode structure shown in the 1st example.
[Drawing 3] It is explanatory drawing showing the example of others of the electrode structure shown in the 1st example.
[Drawing 4] It is explanatory drawing showing the plasma treatment room composition of the 2nd example by this invention.
[Drawing 5] It is explanatory drawing showing the plasma treatment room composition of the 3rd example by this invention.
[Drawing 6] It is explanatory drawing showing the plasma treatment room composition of the 4th example by this invention.
[Drawing 7] It is explanatory drawing showing the plasma treatment room composition of the 5th example by this invention.
[Drawing 8] It is explanatory drawing showing the example of others of the electrode structure shown in the 5th example.
[Drawing 9] It is explanatory drawing showing the example of others of the antenna electrode structure shown in the 5th example.
[Drawing 10] It is explanatory drawing showing the plasma treatment room composition of the 6th example by this invention.
[Drawing 11] It is explanatory drawing showing the electrode composition of the 7th example by this invention.
[Drawing 12] It is explanatory drawing showing the plasma treatment room composition of the example of the octavus by this invention.
[Drawing 13] It is explanatory drawing showing the plasma treatment room composition of the 9th example by this invention.
[Drawing 14] It is explanatory drawing showing the plasma treatment room composition of the 10th example by this invention.
[Drawing 15] It is explanatory drawing showing the plasma treatment room composition of the 11th example by this invention.
[Drawing 16] It is explanatory drawing showing the plasma treatment room composition of the 12th example by this invention.
[Drawing 17] It is explanatory drawing showing the composition of the plasma treatment equipment of the conventional technology.
[Description of Notations]
1 -- power supply, 2 -- electrode, and 2 -- '-- electrode, a 2"-- electrode, and 2"' -- electrode and 3 -- susceptor -- 4 -- processing object and 5 -- the insulating section, 6 -- side-attachment-wall section, 7 --

gas supply means, and 8 -- a conductor -- a wall -- 8'-- a conductor -- a wall, 9 -- processing room, and 10 -- a power supply, 11 -- antenna, and 12 -- power supplies -- 13 [-- Electric field which a periphery electrode generates,] -- A magnetic field generating means, 14 -- Electric field, 14' which an antenna generates 15 [-- Insulator covering, 18 / -- Polar zone,] -- Line of magnetic force, 16 -- An antenna electrode, 17 19 [-- A power-output edge, 22 / -- Insulating section,] -- The antenna section, 20 -- A power-input edge, 21 23 [-- A stage electrode, 53 / -- A counterelectrode, 55 / -- A processing substrate, 56 / -- Bias power supply, 57 / -- A RF generator, 58 / -- A coil, 70 / -- A processing room, 71 / -- A counterelectrode, 81 / -- A RF generator, 82 / -- A RF generator, 87 / -- A cover plate, 91 / -- Covering.] -- A periphery electrode, 51 -- A processing room, 52

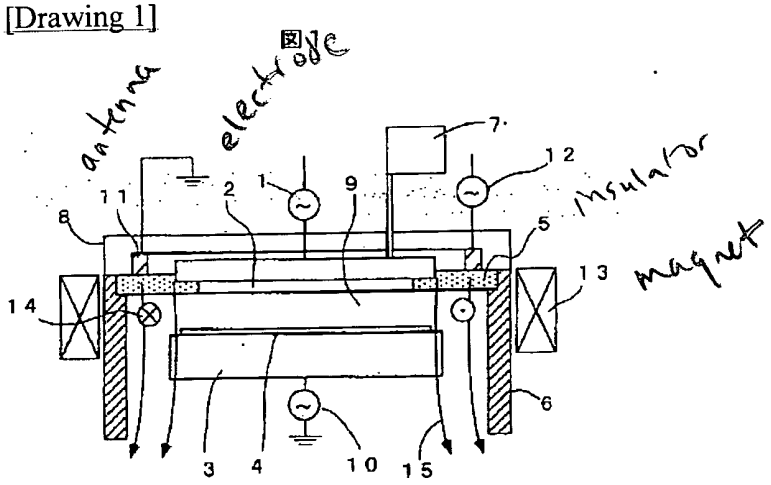
[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

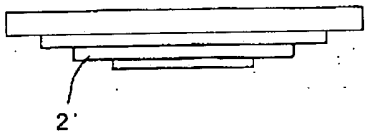
[Drawing 1]



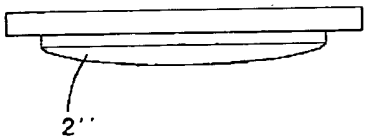
[Drawing 2]

図2

(イ)

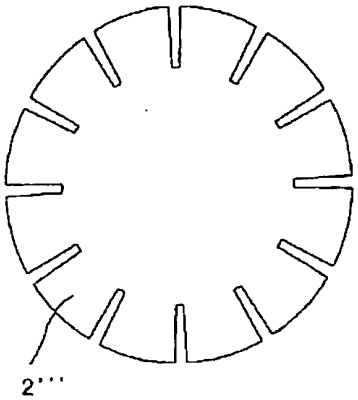


(ロ)



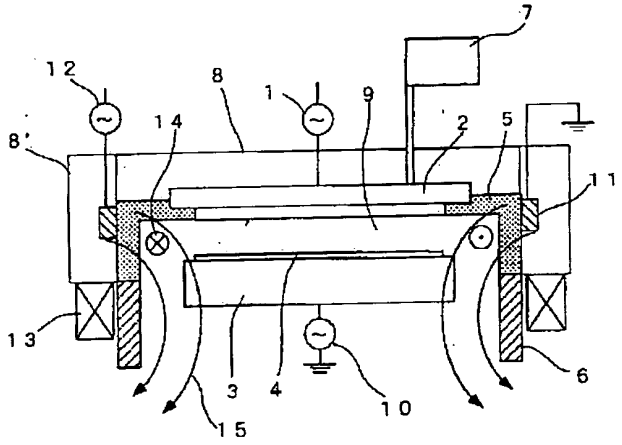
[Drawing 3]

図3



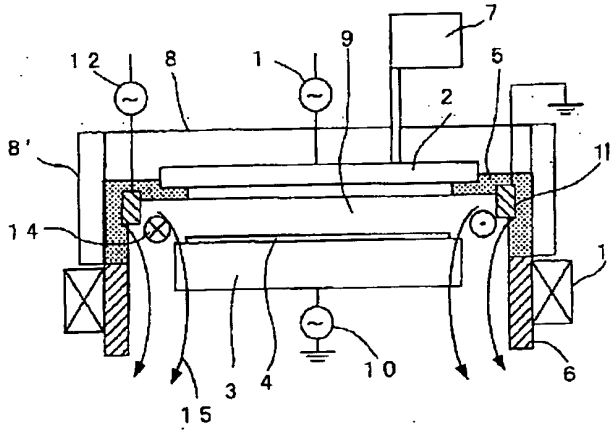
[Drawing 4]

図4



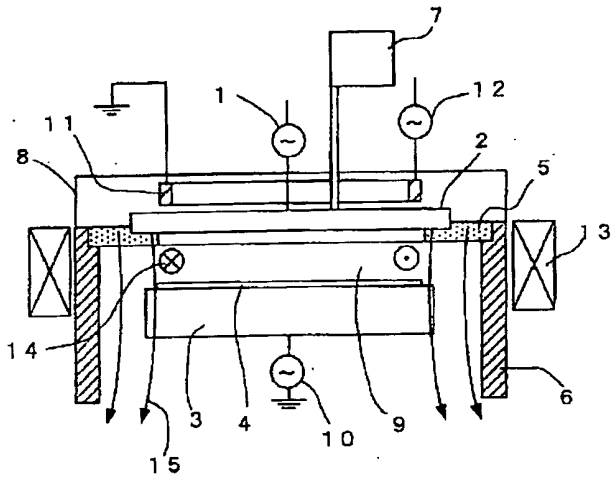
[Drawing 5]

図5



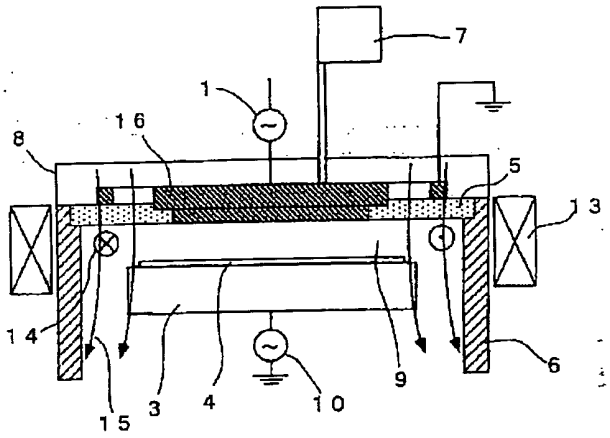
[Drawing 6]

図6



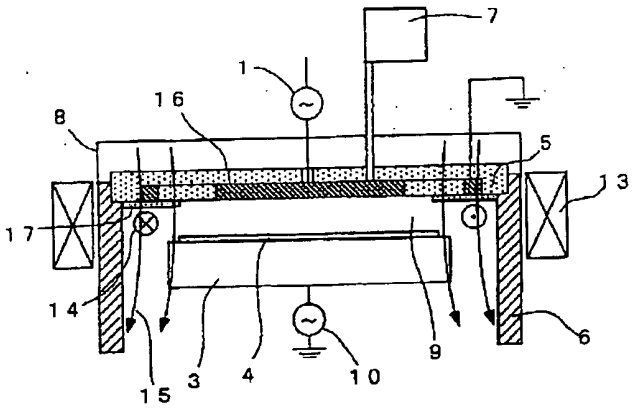
[Drawing 7]

図7



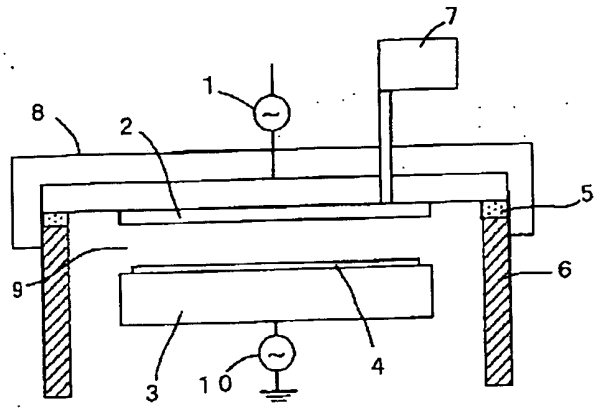
[Drawing 8]

図8



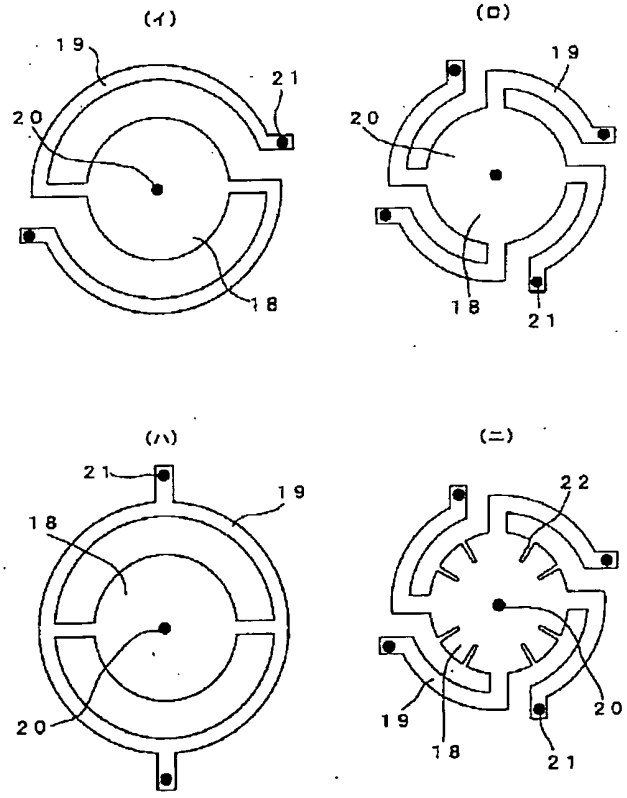
[Drawing 17]

図17



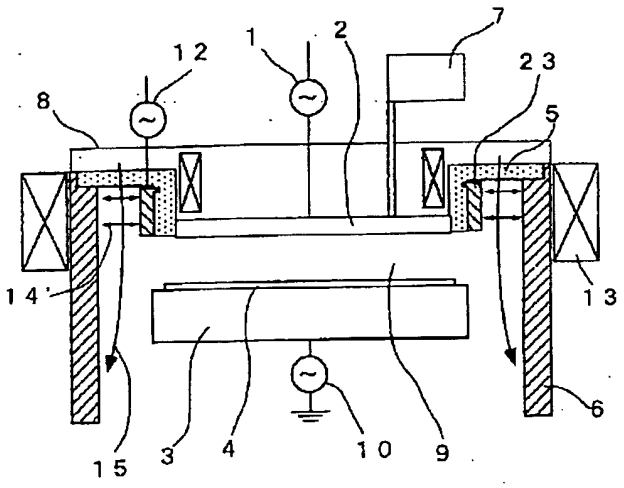
[Drawing 9]

図9



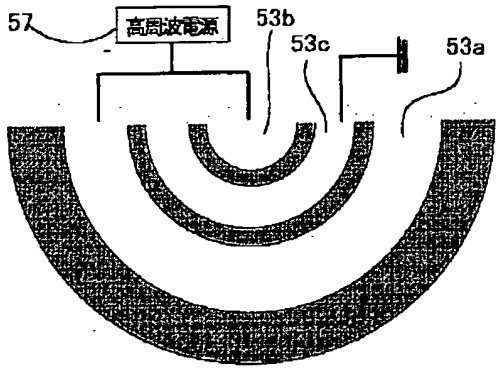
[Drawing 10]

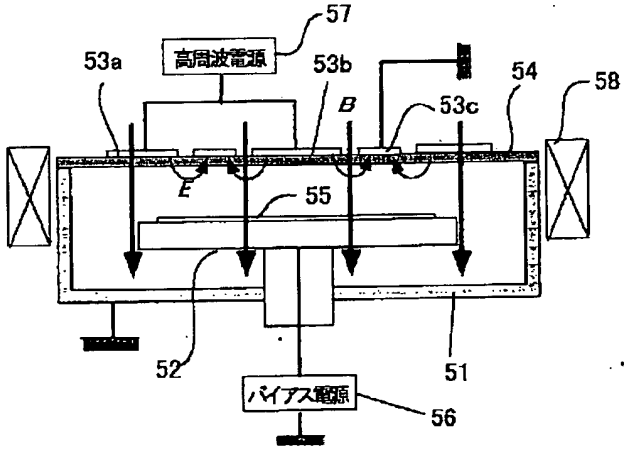
図１０



[Drawing 11]

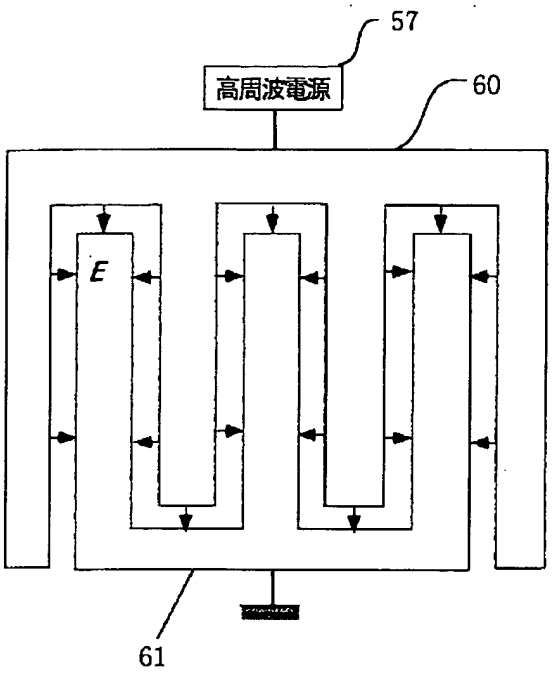
図１１





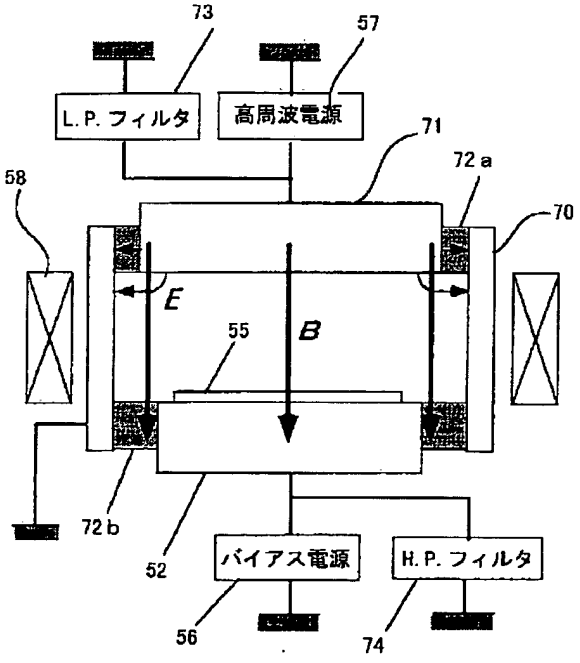
[Drawing 12]

図１２



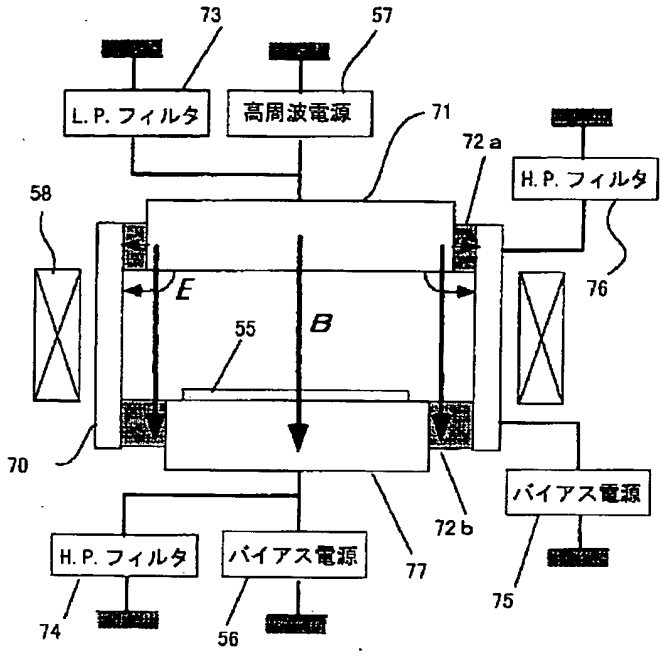
[Drawing 13]

図１３



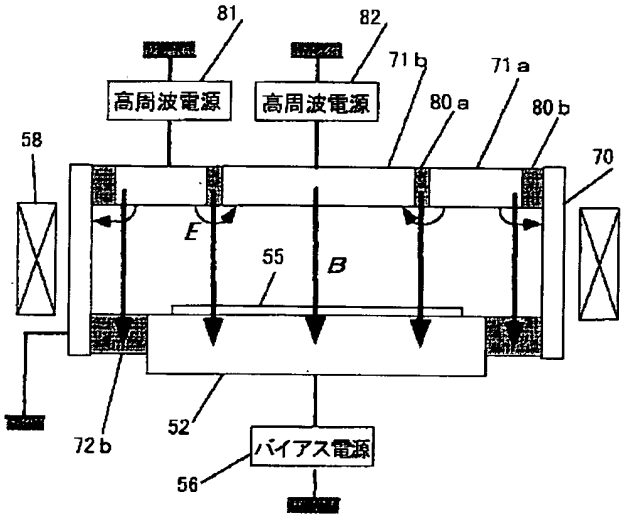
[Drawing 14]

図１４



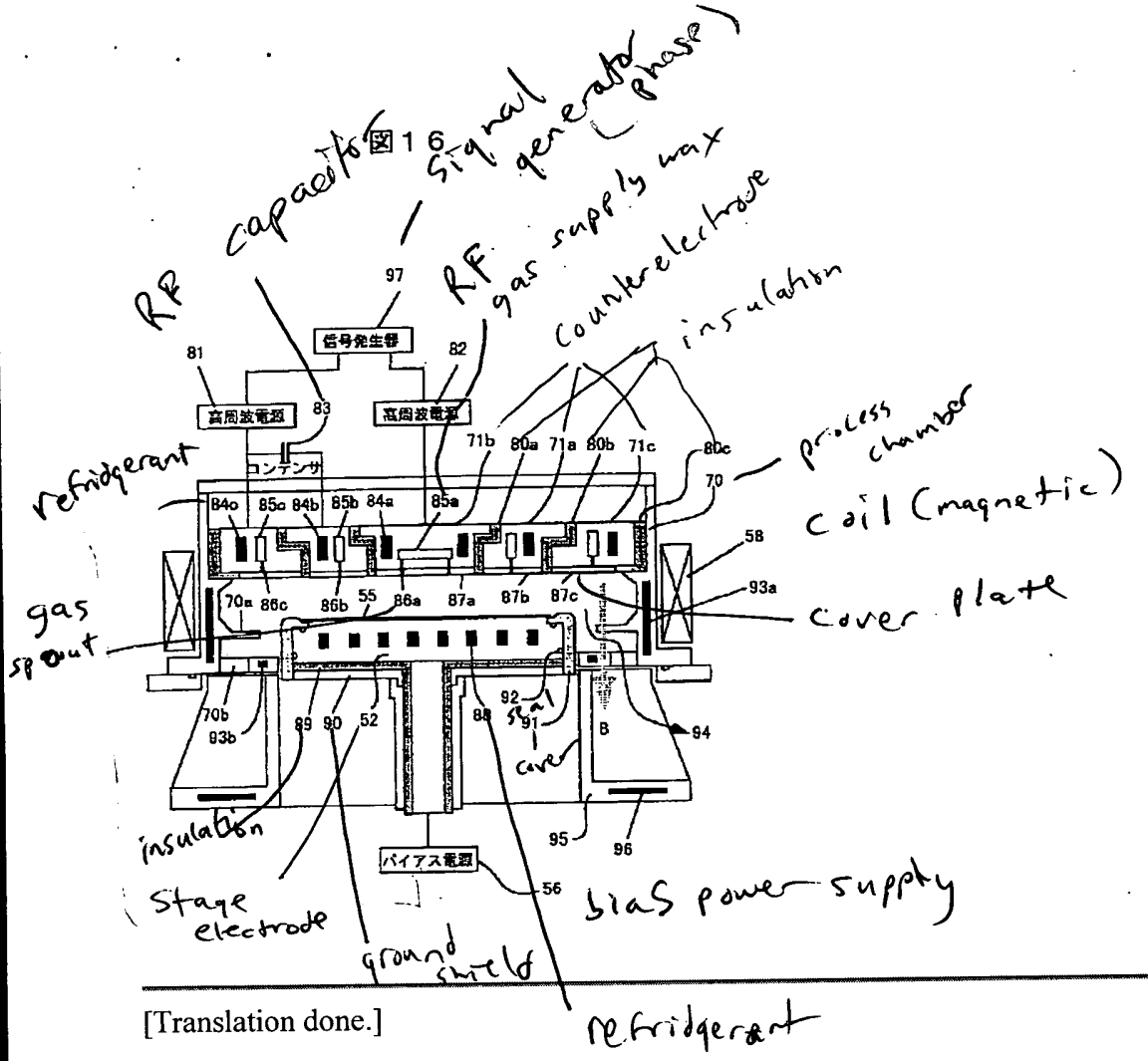
[Drawing 15]

図１５



[Drawing 16]

図16



[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to plasma treatment equipments, such as detailed pattern formation of a semiconductor device or a liquid crystal display element and suitable plasma etching to process uniformly to the diameter substrate of macrostomia, suitable plasma CVD for formation of a fine structure thin film, and a plasma polymerization, and the plasma treatment method especially about the processor equipped with the plasma production means.
[0002]
[Description of the Prior Art] It is the energy of incidence ion to the active species and the processing substrate which influence processability ability with the plasma treatment equipment which processes a semiconductor device and a liquid crystal display element using plasma. The directivity of ion, homogeneous control of plasma treatment, and the productivity of plasma treatment are required.
[0003] About control of active species, there is a thing of an parallel plate electrode method which is indicated by JP,57-131374,A, for example, and the conventional example of the plasma treatment equipment of this parallel plate electrode method is shown in drawing 17 .
[0004] With the equipment of drawing 17 , it is maintained at the vacua by the flueing means which the processing room 9 surrounded by the electrode 2 of the shape of the cylinder-like side-attachment-wall section 6, the insulating section 5, and a disk does not illustrate, and the gas supply means 7 supplies a raw gas to a processing room through the electrode 2 which has the function of a gas introduction way. Usually, the side-attachment-wall section 6 is grounded and is insulated by the insulating section 5 in the electrode 2. The electrode 2 and the susceptor 3 constitute the parallel plate electrode, and when a power supply 1 applies power between this parallel plate electrode, the raw gas of the processing room 9 interior plasma-izes them.
[0005] The wafer 4 of a processing object is installed by the lower part of a processing room on the susceptor 3, and micro processing is performed by the active species in the raw gas activated by the plasma generated in the processing room 9, and plasma (radical). At this time, the amount of the active species which exists partly and the state of a ratio which the density of plasma and the temperature of the electron in plasma change, and influence simultaneously decomposition of a raw gas, i.e., the performance of micro processing, with the input power which a power supply 1 applies, the pressure in the processing room 9, the width of face of the gap between an electrode 2 and a susceptor 3, etc. change.
[0006] There is a method which is indicated by JP,4-239128,A about control of an ion energy.
[0007] Independently, this establishes the emission magnetic field where these are perpendicular in an parallel monotonous electrode, and it enables it to control independently the energy of the ion which controls auto-bias voltage and carries out incidence to a substrate by the magnetic field, and the RF-generator output which generates plasma by this carries out highly precise etching processing, without giving a damage.
[0008] While raising the directivity of ion, there is a method which is indicated by JP,8-195379,A as a

method of not reducing processing speed.
[0009] This realizes plasma treatment which was excellent in the density distribution controllability of plasma while generating high-density plasma in low voltage by generating the plasma to which capacity-coupling nature and inductive-coupling nature were intermingled.
[0010] There is equipment currently indicated by JP,61-283127,A as plasma treatment equipment which controls the homogeneity of plasma treatment.
[0011] With this equipment, the electrode which impresses RF power is divided into plurality, and improvement homogeneous by controlling independently the power impressed to each electrode is aimed at.
[0012] A big problem when raising productivity is falling, the rate, i.e., the product yield, of an excellent article in the inside of the element which the film's was formed in the internal surface of a processing room in processing of etching, plasma CVD, etc., and these exfoliated, led to generating of dust, and production of the semiconductor device of high accumulation and the liquid crystal display element produced. Moreover, while continuing production, a processing property changes and the problem that the product yield falls is also.
[0013] The depository film formed in the processing indoor wall by plasma treatment repeats the temperature change by the heat input change from plasma, if stress occurs and a film becomes thick in a depository film by this, this stress will become more than adhesion force, ablation of a film will start and generating of dust will turn into generating of dust.
[0014] In order to remove the depository film formed in the internal surface, the plasma treatment equipment which raises the energy of the ion which carries out incidence to the field in which these depository film was formed, and raises the removal rate of a depository film is indicated by JP,8-330282,A.
[0015] Moreover, the depository film of an internal surface is changed into the volatile matter, and the method of discharging by the evacuation system is shown. Non-gas-like material is arranged to the processing interior of a room, this material and plasma react, reactant chemical species are generated, this reacts with a depository film and the method of changing a depository film into volatile goods and cleaning it is indicated by JP,7-153751,A.
[0016] The equipment which prepared the electrode cooled by the method of controlling the internal surface of a plasma treatment room to constant temperature as a method of stabilizing the processing property of plasma treatment at JP,6-188220,A and JP,61-8927,A, and the fluid which makes parallel structure is indicated.
[0017]
[Problem(s) to be Solved by the Invention] Reduction of uniform processing of a selection ratio with furring, highly-efficient-izing of a processing configuration, and the diameter substrate of macrostomia and dust generating is further needed with high integration of a semiconductor device, and diameter[of macrostomia]-izing of a production board.
[0018] 1) One of the factors which influence greatly processing properties, such as selection ratios, such as etching processing by plasma and CVD processing, a processing configuration, and membraneous quality, is active species generated by electronic collision in plasma. The yield of this active species and the active species to generate are decided by the energy situation of the electron in plasma.
[0019] The energy state of the electron in this plasma is decided by the disappearance rate by diffusion of the collision frequency by the processing pressure force, and the electron in plasma etc. It was difficult except changing a statistical distribution by the energy state of the electron in plasma becoming a statistical distribution by the collision with a neutral molecule, ion, etc., and changing a collision frequency like a pressure to control the distribution. Therefore, in order to control an electronic energy state conventionally, the method of controlling the processing pressure force was taken. However, by the method of controlling the processing pressure force, the micro-processing nature of etching processing, coexistence of a selection ratio, etc. become difficult, and coexistence of the covering performance on membrane formation speed, membraneous quality, and the front face of an element becomes difficult in plasma CVD.

[0020] One of the purposes of this invention offers the electronic energy control means in the plasma which became independent of a plasma generating means and ion-energy control means apart from process conditions like the conventional pressure, and it controls the component of active species, and the amount of active species, and its selection ratio is high and it is to offer the plasma treatment equipment whose micro processing is possible.
[0021] 2) It is required to be compatible with the generating technology of active species control, ion-energy control, and low voltage high-density plasma about the homogeneity of plasma treatment.
[0022] Moreover, with diameter[of a large quantity]-izing of a processing substrate, when the gas for processing flows in the periphery section from a substrate core by etching processing or CVD processing, an active species concentration distribution and a distribution of a depository film actualize, and it is becoming difficult to carry out uniform processing all over the diameter substrate of a large quantity. Therefore, in order to solve these problems, it is required to negate the factor which cannot equalize a distribution according to another etching property control factor. As one control factor for that, it is required to be able to adjust the concavo-convex distribution of plasma for a plasma distribution for every process conditions independently of the process conditions of others, such as plasma density and a pressure.
[0023] One of the purposes of this invention is to offer the plasma treatment equipment which has the homogeneous controlling mechanism with which it is compatible with generating of active species control, ion-energy control, and low voltage high-density plasma with a controlling mechanism, and the process conditions of further others can control the homogeneity of plasma independently, and the plasma treatment method.
[0024] 3) Although removing the depository film adhering to a processing indoor side is examined as conventional technology for the reduction in raising dust, evaporation of a depository film takes time to the method of evaporating and exhausting a depository film, and it has the problem of reducing productivity. Moreover, since it is exposed to the radical and ion in plasma, it deteriorates, and the reaction in a wall surface changes, and the field after removing a depository film affects a plasma treatment property etc.
[0025] Moreover, the front face where states, such as a field where RF power is impressed, and a grounded field, differ is intermingled on the plasma treatment indoor wall surface, and the reduction in raising dust corresponding to these is required for it.
[0026] One of the purposes of this invention is to offer the plasma treatment equipment which can work for a long period of time, without generating dust, and is not fall ** about productivity.
[0027]
[Means for Solving the Problem] The above-mentioned technical problem was solved by the following meanses by this invention.
[0028] 1) Give energy to the electron in the plasma generated more in capacity-coupling electric discharge for the plasma generating means by capacity-coupling electric discharge, and a means to emit an electromagnetic wave into the plasma by the electromagnetic wave, control electronic energy and electron density, and consider as a means to adjust the component ratio of active species, and the amount of active species.
[0029] The magnetic field where the antenna for switching on the electrode and electromagnetic wave of an parallel plate electrode and the switched-on electromagnetic wave may advance the inside of plasma is established in the processing interior of a room, it installs so that the plasma production field of this antenna may lap with the plasma production field of an parallel plate electrode, and electronic energy and electron density are controlled by mixture of the plasma of two types of the plasma by the plasma generated in the parallel plate electrode, and the electromagnetic wave switched on from the antenna. Electronic energy can be controlled now by electro magnetic radiation from an antenna, by changing the power rate supplied to electro magnetic radiation from capacity-coupling electric discharge and an antenna, can change the electronic energy situation in plasma, and can control the amount of active species, and active species.
[0030] Moreover, it is made adjustable including the conditions which a electron cyclotron resonance

generates to the frequency of the electromagnetic wave to which the magnetic field intensity of the above-mentioned magnetic field is emitted, and enabled it to control by this the energy level given to the electron in plasma by changing magnetic field intensity.
[0031] 2) About homogeneous control of plasma, the antenna which emits an electromagnetic wave into plasma is formed more than a duplex, and the distribution of plasma was controlled by means to control the electromagnetic wave emitted from each antenna.
[0032] It is as having described active species generating control and having indicated into the portion that electron density can control an electromagnetic wave by emanating into plasma.
[0033] dividing into plurality the electrode of the capacity-coupling electric discharge as an antenna means which emits an electromagnetic wave, and making each inter-electrode one generate high-frequency voltage -- each inter-electrode one -- an electromagnetic wave -- radiation **** -- it was made like
[0034] The power of the electromagnetic wave emitted from each inter-electrode one is controllable by controlling the high-frequency voltage generated in inter-electrode [which was divided]. The phase of the high-frequency voltage impressed to each electrode as control means of the high-frequency voltage which generates inter-electrode was controlled.
[0035] 3) In order that it might be accelerated by RF electric field and ion might carry out incidence in a plasma treatment room by the electrode which impresses a RF, the film which adheres to an electrode front face by the energy of this ion was removed, and the raising dust by the depository film was reduced.
[0036] While using the material which reacts to an electrode front face with the active species generated in plasma treatment, and does not generate the nonvolatile matter, heat transfer to the cooled electrode was raised, and in order to reduce temperature change, it was made the structure where a pressure was heightened. While reducing the raising dust by a nonvolatile reactant organism being formed in a front face by this, temperature change was reduced, the reaction in a front face was stabilized, and change of a plasma treatment property was prevented.
[0037] Generating of the film internal stress by heat change is prevented, and it was made for ablation of a film not to occur by keeping the temperature of a processing indoor wall surface constant about the other portion. Moreover, by keeping temperature constant, the reaction in a front face was stabilized and change of a plasma treatment property was prevented.
[0038]
[Embodiments of the Invention] Hereafter, one example of this invention is shown in drawing 1 - drawing 16 .
[0039] Drawing 1 explains the 1st example.
[0040] In drawing 1 , the susceptor 3 which supports a processing object is installed in the processing room 9, and a processing object 4 is placed on the aforementioned susceptor 3. A processing object 4 is a wafer for semiconductor devices. Some walls of a processing room serve as an electrode 2, and it forms an parallel plate electrode between the susceptors 3 which also have the function of an electrode. Although it is usually plate-like, an electrode 2 may be plate-like, may have a stair-like level difference like the drawing 2 (b), and, as for the susceptor 3 and the processing object 4, may have a curved-surface portion like the drawing 2 (b). Even if an electrode 2 is which case of drawing 1 , the drawing 2 (b), and the drawing 2 (b), below, the group of an electrode 2 and a susceptor 3 is called parallel plate electrode. Usually, although the electrode 2 is in contact with the processing room 9, covering which consisted of insulators etc. may be between an electrode 2 and the processing room 9. The raw gas is introduced into the processing room 9 by the gas supply means 7, for example, the electrode 2 may have the function of a raw-gas introduction way like drawing 1 .
[0041] Furthermore, the processing room 9 is exhausted by the exhaust air means which is not illustrated, and is maintained at the low voltage state. The processing room 9 is surrounded in the side-attachment-wall section 6 grounded by the shape of a cylinder, and an electrode 2 and the side-attachment-wall section 6 are electrically insulated by the insulating section 5. A power supply 1 is the combination of AC power supply and a matching circuit. With the power which the power supply 1

applied to the parallel plate electrode, the raw gas of the processing room 9 interior plasma-izes, and plasma activates a raw gas and generates the active species of various kinds. Furthermore, the antenna 11 is installed near the insulator 5, and an insulator 5 has the function of the aperture which introduces into the processing room 9 the electromagnetic wave which an antenna 11 generates. Antennas 11 may be loop antennas which had one or more input edges and outgoing ends of power, and were rolled more than a reel or it, may be division loop antennas which divided the reel into plurality, and even if they are other configurations, they should just be antennas which emit an electromagnetic wave. Although the power supply 12 supplies power to the antenna 11, a power supply 1 may apply power to an electrode 2 and an antenna 11.

[0042] Moreover, if insulating regions, such as a slit which checks the induced current to an electrode 2, are prepared as shown in drawing 3 when an antenna 11 guides current to an electrode 2, it will become easy to introduce the power of an antenna into the processing interior of a room. An antenna 11 carries out induction of the electric field 14 as shown in drawing 1 to the processing interior of a room, and generates plasma. Since this antenna generates plasma near the side-attachment-wall section 6, the state of the wall surface of the side-attachment-wall section 6 is controllable by adjusting the power by the power supply 12.

[0043] Moreover, although the radical which the plasma by the antenna 11 excites is diffused and it permeates and goes also to the gap of an parallel plate electrode, since composition differs from the active species which the plasma by the parallel plate electrode excites, control of the radical composition inside processing loculus is possible by adjustment of the power supplied to an antenna.

[0044] With the equipment of drawing 1 , a magnetic field can be further added to the processing interior of a room by the magnetic field generating means 13. For example, the magnetic field of a distribution as shown by line of magnetic force 15 using a cylinder-like solenoid coil can be generated. If the vibration frequency of electric field 14 and the intensity of a magnetic field 15 are united so that a electron cyclotron resonance may be started when the oscillating electric field 14 and line of magnetic force 15 which an antenna generates are in general perpendicular, plasma is efficiently generable especially. For example, when the frequency of oscillating electric field is 68Mhz(es), a electron cyclotron resonance happens near 24 gausses of magnetic field intensity.

[0045] Moreover, if magnetic field intensity is adjusted in the range near a electron cyclotron resonance magnetic field, adjustment of a radical component ratio can be performed and the performance of micro processing can be optimized.

[0046] Furthermore, in the place where magnetic field intensity is stronger than an electronic cyclotron magnetic field, an electromagnetic wave can spread the inside of plasma along a magnetic field. Therefore, the increase in efficiency of plasma production is attained by setting up the distribution of an antenna and a magnetic field so that it may pass through the place where the line of magnetic force which passes along an antenna like drawing 1 wants to generate the plasma of the processing interior of a room.

[0047] Next, drawing 4 explains the 2nd example.

[0048] Although the component with the fundamental equipment of drawing 4 is almost the same as the equipment of drawing 1 , in drawing 1 , it differs in that the antenna 11 currently installed in the upper surface of the processing room 9 is installed in the side of a processing room. in drawing 4 , the electromagnetic wave of an antenna 11 does not leak outside -- as -- a conductor -- although surrounded by wall 8' -- a conductor -- a wall 8 and a conductor -- wall 8' may be the thing of one Another feature of the equipment of drawing 4 sets up caudad the installation position of the magnetic field generating meanses 13, such as a solenoid coil, and is that it arranges so that the line of magnetic force 15 which passes the antenna 11 installed in the processing room side may pass through the processing interior of a room. As the example of drawing 1 also described, when this adds a magnetic field stronger than a electron cyclotron resonance magnetic field, the electromagnetic wave which an antenna emits becomes easy to enter into the plasma of the processing interior of a room, and is gathering the generation efficiency of plasma.

[0049] Next, drawing 5 explains the 3rd example.

[0050] Although the equipment of drawing 5 has the almost same composition as the equipment of drawing 4 , it differs in that the antenna 11 is installed in the processing indoor section. If an antenna is directly exposed to the plasma of the processing interior of a room, when the antenna itself can be shaved and it will have a bad influence on micro processing, the material which can be hard to delete by plasma on the surface of an antenna may be coated, or covering which was able to be done at the antenna with the insulator may be put. By installing an antenna in the processing indoor section like the example of drawing 5 , when the space which installs an antenna in the processing room upper surface or the processing room side cannot be taken, an antenna can be formed.
[0051] Next, drawing 6 explains the 4th example.
[0052] Although the composition of the equipment of drawing 6 is the same as the equipment of drawing 5 , with the equipment of drawing 6 , the point that the antenna 11 is installed in the upper part of an electrode 2 has been the feature. In the case of the equipment of drawing 6 , an electrode 2 has the insulating sections, such as a slit as shown in drawing 3 , and some electromagnetic fields [at least] as for which an antenna 11 carries out induction can pass an electrode 2, it can spread in the processing room 9, and plasma can be generated, or energy can be given to plasma now. In this case, in order for an parallel plate electrode and an antenna to generate plasma in the gap of an electrode 2 and a susceptor 3, antenna injection power adjusts the electronic energy of the plasma of processing-object right above, and it becomes possible to raise the performance of micro processing.
[0053] Next, drawing 7 explains the 5th example.
[0054] The feature over the equipment of drawing 1 of the equipment of drawing 7 is the point of using the antenna electrode 16 which the antenna 11 and electrode 2 of drawing 1 unified.
[0055] The example of an antenna electrode is shown in drawing 9 . An antenna electrode consists of one or more antenna sections 19, input edges 20, and outgoing ends 21 which were connected with one or more polar zone 18 there. An example of an antenna electrode is shown in the drawing 9 (b), the drawing 9 (b), the drawing 9 (c), and the drawing 9 (d). A slit-like insulating region is prepared so that the induced current which the electromagnetic wave which the antenna section 19 especially emits by the drawing 9 (c) causes in the polar zone 18 may be checked, and the radiant efficiency of the electromagnetic wave of the antenna section is gathered.
[0056] In the example shown in drawing 7 or drawing 9 , although the polar zone and the antenna section are in a coplanar mostly, they may have composition with three-dimensional polar zone and antenna section. For example, there is also an antenna electrode in which the antenna section is installed right above the polar zone. A part of power applied to the input edge 20 by the power supply 1 is used for plasma production by the parallel plate electrode which the polar zone 18 and a susceptor 3 form, and the remainder is emitted as an electromagnetic wave from the antenna section 19, and generates plasma to the processing interior of a room. An outgoing end may be grounded, and in order to maintain the voltage of the polar zone of an antenna electrode, after it minds the voltage maintenance means constituted by the capacitor etc., you may ground it.
[0057] Moreover, an input edge and an outgoing end may be replaced and you may connect. If this antenna electrode is used, an electrode and the power supply which was in one antenna at a time can be managed with one. Although the polar zone of an antenna electrode is exposed to a processing room and the antenna section is in the processing outdoor section in drawing 7 , you may attach to the polar zone covering which consisted of insulators etc.
[0058] Moreover, as shown in drawing 8 , the antenna section may be installed in the processing indoor section, and you may cover an insulator etc. in the antenna section. The equipment of drawing 7 or drawing 8 can have the almost same effect as the equipment of drawing 1 , and can improve the performance of micro processing of a processing object.
[0059] Next, drawing 10 explains the 6th example.
[0060] With the equipment of drawing 10 , in order to generate plasma in the about six side-attachment-wall section of the processing interior of a room, the power supply 12 which applies power is formed between the periphery electrode 23 and the side-attachment-wall section 6. Since the plasma which the periphery electrode 23 generates is near the side-attachment-wall section, it can perform control of the

state of a side-attachment-wall section wall surface, and can improve the performance of micro processing. Moreover, the plasma from which a thing which is different in the frequency of a power supply 1 and a power supply 12, then electron temperature differ is generated, and the performance of micro processing can be optimized by regulation of a radical component ratio like the equipment of drawing 1 . Furthermore, the magnetic field generating means 13 is installed so that the direction of electric-field 14' which the periphery electrode 23 generates may go direct mostly with line of magnetic force 15, and if it sets up so that magnetic field intensity may turn into electron cyclotron resonance magnetic field intensity near the periphery electrode, the efficiency of the plasma production by the periphery electrode can be gathered.

[0061] Next, drawing 11 explains the 7th example.

[0062] processing room: -- the inside of 51 -- stage electrode: -- 52 and counterelectrode:53 counter and are prepared processing room: -- the main part of 51 is formed by the grounded metal vessel, and the upper part is formed by quartz board:54 -- having -- **** -- a processing room -- :51, the quartz board, and the joint of each electrode have vacuum seal structure, and have structure which can exhaust the inside of processing room:51 to a vacuum Moreover, a processing room: There is a raw-gas feeder style which is not illustrated in 51, and the pressure in processing room:51 can be controlled now by the exhaust air controlling mechanism which is not illustrated while supplying a raw gas to the target pressure.

[0063] stage electrode: -- 52 -- processing substrate: -- it has the structure where 55 can be ****(ed) and the temperature of processing substrate:55 under plasma treatment can be controlled now by the temperature-control mechanism which is not illustrated Moreover, bias power supply which controls the energy of the ion which carries out incidence to a processing substrate to stage electrode:52 (2MHz): 56 is connected.

[0064] counterelectrode: -- 53 -- RF impression ring electrode: -- from 53a, 53b, and ground ring electrode:53c -- changing -- **** -- RF impression ring electrode:53a and 53b **** -- 100MHz RF-generator: -- 57 is connected and ground ring electrode:53c is grounded

[0065] processing room: -- the periphery of 51 -- coil: -- 58 is prepared and it has come to be able to carry out the formation formation of the magnetic field in the processing interior of a room

[0066] Next, the example of operation in the etching processing by this example is explained.

[0067] stage electrode: -- 52 -- processing substrate: -- 55 is carried in and laid The etching gas (fluoridation carbon system gas) of a setting flow rate is supplied from the source of etching gas supply which is not illustrated, and exhaust air is controlled so that the pressure of the processing interior of a room is set to 1Pa. The silicon-oxide film and silicon film which are an insulator layer of a semiconductor device are formed in the processing substrate. this processing substrate -- stage electrode: -- while making an electrostatic target stick to 52, from the gaseous helium source of supply which is not illustrated, helium gas is supplied between a substrate and stage electrode:52, and the temperature rise under etching processing of a processing substrate is prevented

[0068] The RF impression ring electrode which is a counterelectrode: Supply 1.5kW of 100MHz RF power to 53a and 53b, and generate plasma by electric discharge. RF impression ring electrode: Since it dissociates by quartz board:54 between 53a, 53b, and the vacuum atmosphere of the processing interior of a room, the energy supply to plasma is performed by capacity coupling. In this case, since the electric field formed in the interface of a sheath and plasma are small, an electronic energy distribution is close to the Maxwell Boltzmann distribution.

[0069] RF impression ring electrode: An electromagnetic wave is emitted as the RF electric field E are formed between 53a, 53b, and ground ring electrode:53c, a magnetic field is formed from this electric field and electric field are formed further. Since plasma density becomes three 1010-/cm, although the electromagnetic wave emitted is not made by advance by electric discharge by capacity coupling into plasma, since electric field occur near quartz board:54, an electron is directly accelerated by this electric field, and energy can be received. In this case, although the electron which receives energy is only an electron near the quartz board and there are few the rates, an electronic energy level becomes high compared with the plasma generated by capacity coupling.

[0070] Thus, the energy supplied to plasma has two kinds of paths, what is depended on capacity coupling, and direct heating by RF electric field, and since the energy levels which an electron receives according to each path differ, an electronic energy situation is changeable in this example, by changing the power rate of each path. If it considers as the method of changing, there are a method of changing the thickness of quartz board:54, and a method of changing the interval of a RF ring electrode and a ground ring electrode. If thickness of a quartz board is thickened, the impedance of capacity coupling will become high, discharge voltage becomes high, the rate of electro magnetic radiation increases, the power rate supplied by capacity coupling falls, and an electronic energy level becomes high. If the interval of a RF ring electrode and a ground ring electrode is narrowed, RF electric field become strong, the rate of electromagnetic radiation will increase and an electronic energy level will become high similarly. If it is made these reverse, it can bring close to the energy level by electric discharge of only capacity coupling.

[0071] Bias power supply: If 2MHz RF power is switched on 500W from 56, the voltage of 700Vpp(s) will occur, the ion from plasma can be accelerated, incidence can be carried out to a substrate, on a substrate front face, by assistance of ion, the etching gas (fluoridation carbon system gas) decomposed by plasma, a silicon-oxide film, and a silicon film react, and etching advances.

[0072] If an electronic energy level is high, decomposition of fluoridation carbon system gas will progress, a fluorine system radical amount will increase, and the etch rate of a silicon film will improve. Moreover, on the conditions to which such gas decomposition progressed, an etching cross-section configuration also becomes near perpendicularly, and it is easy to become an order taper configuration on the conditions to which decomposition does not progress. In manufacture of a semiconductor device, it is required to make as small as possible the etch rate of a silicon film to the etch rate of the silicon-oxide film which is an insulator layer, and to bring it close as perpendicularly [an etching cross-section configuration] as possible. It is required to find the conditions which the decomposition situation of fluoridation carbon system gas is controlled [conditions] appropriately for that purpose, and reconcile both.

[0073] In this invention, by stating previously and adjusting the thickness of a quartz board, the interval of a RF ring electrode and a ground ring electrode, etc. like, the decomposition situation of fluoridation carbon system gas can be controlled, and optimization of an etching property can be performed.

[0074] Moreover, a RF impression ring electrode: The distribution of plasma is also changeable by changing the size of 53a, 53b, and a ground ring electrode.

[0075] Next, the electronic energy control method of others in this example is explained.

[0076] RF impression ring electrode: In this example, although it explained previously that the RF electric field E were formed between 53a, 53b, and ground ring electrode:53c, and an electromagnetic wave was emitted, since it was non-magnetic field conditions, advance of an electromagnetic wave was not completed into plasma, but it only supplied energy to the electron near the quartz board. this control method -- coil: -- current is passed to 58, a magnetic field B is formed, and the electromagnetic wave enabled it to go on in plasma Moreover, it enabled it to set up the intensity of a magnetic field including the conditions which start a electron cyclotron resonance to the frequency of an electromagnetic wave, and the energy level given to an electron is controlled by radiation of the electromagnetic wave to capacity-coupling electric discharge plasma, and control of magnetic field intensity, and it enabled it to control by them in the suitable electronic energy state.

[0077] Although the conditions which can advance in plasma can do an electromagnetic wave if even the frequency of 100MHz forms a magnetic field, a magnetic field must be the right-angled direction mostly to the electric field of an electromagnetic wave at this time. Therefore, acceleration of the electron by RF electric field is restrained by the magnetic field, and the energy which an electron receives from RF electric field is slight, and only raises an electronic energy state slightly. Therefore, it is effective for increasing the electron of low energy, such as generation of active species.

[0078] If it is set as 30-40G near the magnetic field intensity which starts a 100MHz electron cyclotron resonance, energy is efficiently supplied to the electron in plasma from the RF electric field of an electromagnetic wave, and an electronic energy level can be raised to more than ionization level, and

can promote decomposition of etching gas.
[0079] Thus, by changing magnetic field intensity, electronic energy can be controlled from the level suitable for generating a radical to more than ionization level, the decomposition situation of etching gas is made suitable by adjustment of magnetic field intensity, and optimization of an etching property can be attained.
[0080] Next, drawing 12 explains the example of the octavus.
[0081] The RF impression ring electrode which forms counterelectrode:53 which show this example to drawing 11 : It is the example of others to the portion equivalent to 53a, 53b, and ground ring electrode:53c.
[0082] RF impression plate electrode:60 which consist of RF impression plate electrode:60 and ground plate electrode:61 that it seems that it is shown in drawing 12 , and face a pectinate, and a ground plate electrode: RF electric field arise among 61 and an electromagnetic wave is emitted by the same principle with the example 1 having explained. Moreover, the point that a RF impression plate supplies power by capacity coupling to plasma is the same as an example 1.
[0083] Except for the point describing above, since it is the same, operation and the function to electronic energy state control are also omitted here.
[0084] Next, drawing 13 explains the 9th example.
[0085] processing room: -- the inside of 70 -- stage electrode: -- 52 and counterelectrode:71 counter and prepare -- having -- **** -- a processing room -- while :70 and each electrode are insulated by insulating material:72a and insulating material:72b -- a processing room -- the joint of :70 has vacuum seal structure and has structure which can exhaust the inside of processing room:70 to a vacuum counterelectrode: -- 71 -- 100MHz RF-generator: -- 57 and low pass filter:73 are connected
[0086] Processing room: 70 is grounded by the ground, and coil:58 prepare it in the periphery and it forms a magnetic field in **** and the processing interior of a room. Moreover, a processing room: There is a raw-gas feeder style which is not illustrated in 70, and the pressure in processing room:70 can be controlled now by the exhaust air controlling mechanism which is not illustrated while supplying a raw gas to the target pressure.
[0087] stage electrode: -- 52 -- processing substrate: -- it has the structure where 55 can be ****(ed) and the temperature of processing substrate:55 under plasma treatment can be controlled now by the temperature-control mechanism which is not illustrated Moreover, bias-power-supply (2MHz):56, a high-pass filter which control the energy of the ion which carries out incidence to a processing substrate to stage electrode:52: 74 is connected.
[0088] Next, the example of operation in the etching processing by this example is explained.
[0089] In drawing 13 , processing substrate:55 are carried in and laid in stage electrode:52. The etching gas (fluoridation carbon system gas) of a setting flow rate is supplied from the source of etching gas supply which is not illustrated, and exhaust air is controlled so that the pressure of the processing interior of a room is set to 1Pa. The silicon-oxide film and silicon film which are an insulator layer of a semiconductor device are formed in the processing substrate. this processing substrate -- stage electrode: -- while making an electrostatic target stick to 52, from the gaseous helium source of supply which is not illustrated, helium gas is supplied between a substrate and stage electrode:52, and the temperature rise under etching processing of a processing substrate is prevented
[0090] Counterelectrode: Supply 1.5kW of 100MHz RF power to 71, and generate plasma by electric discharge. Counterelectrode: A sheath is formed between 71 and plasma and the energy supply to plasma is performed by capacity coupling. In this case, since the electric field formed in the interface of a sheath and plasma are small, an electronic energy distribution is close to the Maxwell Boltzmann distribution.
[0091] counterelectrode: -- 71 and processing room: -- the RF electric field E are formed among 70, and an electromagnetic wave is emitted
[0092] Coil: While passing current to 58 and forming the magnetic field B, it enabled it to set up the intensity of a magnetic field on both sides of the conditions which start a electron cyclotron resonance to the frequency of an impression RF.

[0093] Although the conditions which can advance in plasma can do an electromagnetic wave if even the frequency of 100MHz forms a magnetic field, a magnetic field must be the right-angled direction mostly to the electric field of an electromagnetic wave at this time. Therefore, acceleration of the electron by RF electric field is restrained by the magnetic field, and the energy which an electron receives from RF electric field is slight, and only raises an electronic energy state slightly. Therefore, it is effective for increasing the electron of low energy, such as radical generation.
[0094] If it is set as 30-40G near the magnetic field intensity which starts a 100MHz electron cyclotron resonance, energy is efficiently supplied to the electron in plasma from the RF electric field of an electromagnetic wave, and an electronic energy level can be raised to more than ionization level. Thus, electronic energy is controllable by changing magnetic field intensity from the level suitable for generating a radical to more than ionization level.
[0095] Bias power supply: If 2MHz RF power is switched on 500W from 56, the voltage of 700Vpp(s) will occur, it is accelerated on this voltage and carry out incidence of the ion from plasma to a substrate, and on a substrate front face, by assistance of ion, the etching gas (fluoridation carbon system gas) decomposed by plasma, a silicon-oxide film, and a silicon film react, and etching advances.
[0096] If an electronic energy level is high, decomposition of fluoridation carbon system gas will progress, the amount of fluorine system active species will increase, and the etch rate of a silicon film will improve. Moreover, on the conditions to which such gas decomposition progressed, an etching cross-section configuration also becomes near perpendicularly, and it is easy to become an order taper configuration on the conditions to which decomposition does not progress. In manufacture of a semiconductor device, it is required to make as small as possible the etch rate of a silicon film to the etch rate of the silicon-oxide film which is an insulator layer, and to bring it close as perpendicularly [an etching cross-section configuration] as possible. It is required to find the conditions which the decomposition situation of fluoridation carbon system gas is controlled [conditions] appropriately for that purpose, and reconcile both.
[0097] The decomposition situation of this fluoridation carbon system gas can be controlled by changing magnetic field intensity, and optimization of etching properties, such as an etch-rate ratio of a silicon-oxide film and a silicon film and an etching configuration, can control independently a pressure, and an etching quantity of gas flow and RF power by this invention according to it.
[0098] Next, drawing 14 explains the 10th example.
[0099] The basic composition of this example is the same as the example shown in drawing 13 , and explains only difference here.
[0100] Processing room: 70 is not grounded by the ground but high-pass filter:76 [800kHz bias-power-supply:75,100MHz] are connected.
[0101] Stage electrode: The substrate heating mechanism which is not illustrated is included in 77, and a processing substrate can be heated now from a room temperature to the set point between 500-degree Centigrade.
[0102] Next, the example of operation in the plasma CVD processing by this example is explained.
[0103] stage electrode: -- 77 -- processing substrate: -- 55 is carried in and laid The CVD gas (fluoridation silicon gas + oxygen gas) of a setting flow rate is supplied from the source of CVD gas supply which is not illustrated, and exhaust air is controlled so that the pressure of the processing interior of a room is set to 4Pa. a processing substrate -- stage electrode: -- it puts on 77 and the temperature of a processing substrate is heated to Centigrade 300 degrees counterelectrode: -- 71 -- 100MHz RF power -- 1.5kW is supplied, capacity-coupling electric discharge is generated among stage electrode:77, and CVD gas is made into the plasma state
[0104] counterelectrode: -- 71 -- RF-generator: -- the electric power supply from 57 -- the 100MHz high voltage (1400Vpp) -- generating -- a processing room -- RF electric field occur among :70 Processing room: Although 70 is not grounded, it is in the same state as it was grounded by high-pass filter:76 to the 100MHz RF, and emit the electromagnetic wave of a RF like the example shown in drawing 13 .
[0105] There is much fluoridation silicon gas in the silicon-oxide film with which combination is strong, and decomposition does not progress, but a fluorine is formed, and occlusion is carried out. Like the

example shown in previous drawing 13 by operation of a 100MHz electromagnetic wave and a magnetic field, an electronic energy level is controlled, since the fluorine gas which promoted and dissociated decomposition of fluoridation silicon gas is exhausted, the occlusion to the inside of a silicon-oxide film is reduced, and membraneous improvement can be aimed at. Moreover, since decomposition of fluoridation silicon gas is promoted, the reaction of the silicon and oxygen gas which were dissociated is also promoted and improvement in a membrane formation rate can also be aimed at.
[0106] moreover -- this example -- high-pass filter: -- 74 and high-pass filter: -- by setting it as 200MHz which is the double cycle of the frequency which impresses the frequency characteristic of 76, impression frequency turns into mixed frequency of 100MHz and 200MHz from the nonlinear characteristic which the plasma sheath has, and magnetic field intensity can make resonance conditions also before and behind 70G Changing the rate of the reactance of an adjustment machine and capacitance can also realize the mixed rate of this double cycle.
[0107] In plasma CVD, a silicon-oxide film is formed also in a processing indoor wall, and these separate, and it becomes particle, and has been a technical problem when manufacturing a semiconductor product. this example -- processing room: -- the internal surface of 70 -- bias-power-supply: -- the effect which can impress 75 to 800kHz high-frequency voltage, and raises an incidence ion energy by this, and the fluorine generated by decomposition of fluoridation silicon gas -- a processing room -- since it is **********ed and the silicon-oxide film formed in the internal surface of :70 is removed, a film is not attached to a processing indoor wall surface during membrane formation, but it can reduce generating of particle
[0108] Next, drawing 15 explains the 11th example.
[0109] The basic composition of this example is the same as the example shown in drawing 13 , and explains only difference here.
[0110] counterelectrode: -- 71 -- counterelectrode: -- it consists of 71a and counterelectrode:71b, and each electrode is mutually insulated by insulating material:80a -- having -- **** -- moreover, insulating material:80b -- a processing room -- :70 are insulated each electrode -- RF-generator: -- 81 and RF-generator;82 are connected, and RF-generator:81 and RF-generator:82 generate the same frequency (this example 100MHz) from which the phase shifted, and impress it to each electrode
[0111] the RF from which a phase differs -- counterelectrode: -- 71a and counterelectrode: -- if impressed by 71b, RF electric field will arise between counterelectrode:71a and counterelectrode:71b When a phase is shifted 180 degrees, RF electric field can be generated most efficiently, and if a phase shift is made into 0 times, RF electric field will become the weakest. this phase control and RF-generator: -- the electromagnetic wave power of a RF and counterelectrode:71b which are generated from between counterelectrode:71a and 71b by controlling the power of 81 and 82, and a processing room -- the rate of the electromagnetic wave power of the RF generated from between :70 can be controlled, and the homogeneity of etching processing and plasma CVD processing can be controlled Moreover, a RF generator: The supply-voltage rate by capacity coupling can be controlled by controlling the power of 81 and 82, and homogeneity can also be controlled by it.
[0112] Furthermore, although two sets of RF generators are used in this example, capacitance or a reactance is put in between the power lines supplied to counterelectrode:71a and 71b from one set of a power supply, and the same effect can be acquired even if it carries out shifting a phase.
[0113] Next, drawing 16 explains the 12th example.
[0114] processing room: -- the inside of 70 -- stage electrode: -- 52 and counterelectrode:71 counter and prepare -- having -- **** -- a processing room -- from the etching gas supply mechanism which is not illustrated, :70 supply the etching gas of a setting flow rate, and can maintain it at a setting pressure while being able to exhaust them to a vacuum according to the exhaust air mechanism which is not illustrated
[0115] counterelectrode: -- 71 -- counterelectrode: -- it consists of 71a, 71b, and 71c, and each electrode is mutually insulated by insulating material:80a made from a quartz, and 80b moreover, insulating material:80c -- a processing room -- :70 are insulated counterelectrode: -- 71b -- RF-generator: -- RF-generator;81 are connected to RF-generator:81 and counterelectrode:71a through capacitor:83 at 82 and

counterelectrode:71c RF-generator: -- 81 and RF-generator: -- 82 -- signal generator: -- it has composition which amplifies the signal from 97, and signal generator:97 can control now the phase of the RF signal supplied to each power supply, and an amplitude 100MHz is used for signal frequency by this example.

[0116] Correspondence electrode: 71a, 71b, and 71c are grounded through the low pass filter which is not illustrated, and make the frequency of 10MHz of bias-power-supply:56 through and the high frequency current of bias-power-supply:56 have flowed through the counterelectrode.

[0117] Counterelectrode: Passage:84a which is a refrigerant, and 84b and 84c are prepared in 71, it connects with the circulator which is not illustrated, and the 15-degree C refrigerant which carried out the temperature control circulates.

[0118] counterelectrode: -- 71 -- etching gas supply way: -- 85a, 85b, and 85c are prepared, etching gas is supplied from the source of etching gas supply which is not illustrated, and it has composition spouted from gas supply mouth:86a, and 86b and 86c

[0119] counterelectrode: -- 71 -- cover-plate: -- 87a, 87b, and 87c are being fixed Cover plate: 87a is made from the silicon single crystal plate, gas supply mouth:86aa is prepared in gas supply mouth:86a and a corresponding position, and the size has become 1/10 from 1/4 of gas supply mouth:86a. Cover plate: 87b is made from the silicon single crystal plate, gas supply mouth:86bb is prepared in gas supply mouth:86a and a corresponding position, and the size has become 1/10 from 1/4 of gas supply mouth:86a. Cover plate: 87c is made from SiC.

[0120] processing room: -- 70 -- passage: -- 93a and 93b are prepared, it has composition through which the 50-degree C refrigerant which carried out the temperature control circulates from the circulator which is not illustrated, and the temperature of the internal surface of a processing room can be controlled now at **5 degrees C

[0121] Moreover, a processing room: It shuts up in 70 and board:70a and 70b are formed by one, and it is constituted so that path:94 of exhaust air may become right-angled to magnetic field:B formed by coil:58. In this portion, since plasma crosses and diffuses this magnetic field, plasma does not spread but it has composition shut up.

[0122] stage electrode: -- 52 -- bias-power-supply: -- it has the composition that 10MHz RF power is supplied from 56, and has insulating material:89 and the composition of not causing unusual electric discharge by ground shield:90

[0123] stage electrode: -- 52 -- passage: -- 88 is prepared and it circulates from the circulator which the refrigerant which is -10 degrees C does not illustrate stage electrode: -- processing substrate [of 52]: -- the gaseous helium which controlled the pressure to 3KPa(s) from the gaseous helium source of supply which has prepared the electrostatic adsorption mechanism which is not illustrated in the field in which 55 is laid, and is not illustrated is supplied between a processing substrate and an electrostatic adsorption mechanism, and the temperature of processing substrate:55 under etching processing is controlled at 50 degrees C - 100 degrees C

[0124] stage electrode: -- covering [of the product / circumference / of 52] made from a quartz /: -- 91 is prepared, the field strength which accelerates the ion generated on the hippo front face made from a quartz by the 10MHz RF removes the depository film adhering to a quartz front face, and the thickness is adjusted to the level which hardly **********s covering:91 made from a quartz Moreover, covering:91 and a stage electrode: Seal mechanism:92 are prepared among 52 and the gaseous helium supplied between processing substrate:55 and an electrostatic adsorption mechanism has composition supplied. thereby -- covering: -- 91 -- stage electrode: -- it becomes the composition cooled from 52 and the temperature under etching processing can be controlled in -10 to +10 degrees C

[0125] the lower stream of a river of exhaust air -- depository plate: -- there is 95 and the 25-degree C refrigerant circulates to passage:96 formed in the interior Depository plate: The fin is prepared in the direction which does not increase an exhaust back pressure to 95, and enable it to have taken the large surface area which touches exhaust gas.

[0126] Next, the example of operation in the etching processing by this example is explained.

[0127] this example explains the case where an oxide film is **********ed.

[0128] The inside of processing room:70 is controlled to 2Pa, mixing, supplying and exhausting an argon and C4F8 gas from the source of etching gas supply which is not illustrated. etching gas -- gas supply mouth: -- it is supplied from 86a, 86aa, 86b, and 86bb The counterelectrode to which, as for between counterelectrode:71b, and 71a and 71c, the etching gas of 3KPa(s) was filled, and the temperature control of cover-plate:87a, and 87b and 87c was carried out by this at this time: It is cooled by 71 and controlled by the temperature of 15 degrees C - 50 degrees C. [cover-plate:87a, 87b and 87c, and]

[0129] signal generator: -- 97 -- a 100MHz RF signal -- generating -- counterelectrode:71 -- RF-generator: -- RF power is supplied from 81 and 82 and electric discharge by capacity coupling is generated among stage electrode:52

[0130] counterelectrode: -- 71a and counterelectrode: -- between 71c -- capacitor: -- a phase shifts 90 degrees by 83 and high-frequency voltage is impressed Counterelectrode: The high-frequency voltage between 71b and counterelectrode 71a can be set as gaps arbitrary from 0 times to 180 degrees with the phase control of the RF signal by signal generator:97. Therefore, the high-frequency voltage generated between insulating material:80a can also make it low to make it high with the phase control of signal generator:97 to the high-frequency voltage generated between insulating material:80b. thereby -- insulating material: -- it can also make it low to make power of the electromagnetic wave emitted high from between 80a to the power to which it emanates from between insulating material:80b

[0131] Coil: The electron in plasma is accelerated by the electron cyclotron resonance with the 100MHz electromagnetic wave emitted when power is supplied and the magnetic field of 40G was generated from 30 from the DC power supply which are not illustrated to 58, while electron temperature rises, plasma density also becomes high, and three or more [1x1011cm -] plasma densities can be generated. Moreover, a counterelectrode: A radiation electromagnetic wave is controlled by phase control of the high-frequency voltage impressed to 71, and the distribution of plasma density can be controlled. Moreover, a RF generator: An electron-temperature distribution is also controllable by the plasma distribution by capacity-coupling electric discharge being controllable by controlling the output of 81 and 82, and a radiation electromagnetic wave doubling comparatively and controlling.

[0132] In this example, capacity-coupling electric discharge power raised the rate supplied to the periphery section, and the electric discharge by radiation of an electromagnetic wave raised the supply-voltage rate to a core. Thereby, the electron temperature of a core was high, and the periphery section becomes low, suppresses generating of the fluorine radical in the periphery section to which decomposition of etching gas progresses, and could be made to perform uniform processing.

[0133] Moreover, it becomes difficult for there to be more thickness of the depository film which adheres to the substrate front face of a core under the influence of the flow of etching gas when processing the diameter substrate of macrostomia than the periphery section, for the cone angle of the side of an etching pattern to become large in a core also in an etching configuration, and for a difference to arise in an etching configuration in the core and periphery section, and to form an etching configuration detailed all over the diameter substrate of macrostomia with high precision. In such a case, in this invention, plasma density distribution can be slightly controlled by raising the electromagnetic radiation of a core to a convex distribution, the cone angle of an etching configuration can be controlled by making the ion current of a core increase, and highly precise etching processing can be realized all over the diameter substrate of macrostomia. Since still such processing can set up the phase of the signal of signal generator:97 with the recipe of an etching system like a setup of process conditions, to the process from which etching conditions, such as contact hole etching and through hole etching, differ, it can be set up separately appropriately and does not need to adjust hard composition etc.

[0134] Since high-density plasma can be generated also by the 2Pa low voltage force about an etching performance, a perpendicular contact hole can be etched by the etch rate of 900 nm/min, and it can be compatible in micro-processing nature and productivity. Decomposition of etching gas can be controlled by control of electron temperature also about selectivity, and the process conditions with which micro-processing nature and selectivity are compatible can be expanded.

[0135] Under etching processing, the cover plate of counterelectrode:71 : In order that the temperature

control of the front face of 87a, 87b, and 87c may be carried out and the ion in plasma may accelerate and carry out incidence by the 100MHz high-frequency voltage impressed further, Since it is in the state which the depository film was not formed in the front face, and were ** [the state / front face / of a silicon board] in the front face of cover-plate:87a and 87b, **********ed slightly in SiC on the front face of cover-plate:87c, and the always new field exposed, The reaction in this front face and a gas evolution are maintained at a fixed state.

[0136] stage electrode: -- covering [of 52]: -- acceleration and temperature control of incidence ion according [the front face of 91] to impression of bias power similarly ********** slightly in the front face of a quartz, and the reaction in a front face and a gas evolution are kept constant

[0137] Processing room: Since the internal surface of 70 is grounded, most ion which carries out incidence is not accelerated, but the polymerization film of C and F is formed in the internal surface. Since the front face can always be maintained at a fixed state since an always new film is formed, and the skin temperature is kept at 50 degrees C, there is no gas evolution from a depository film, and it can keep a surface state and a gas evolution constant.

[0138] Since a depository film is not formed in counterelectrode:71 and stage electrode:52 but there is also no transformation of a front face while being able to prevent change of the etching property by repeating etching processing by these, there is almost no generating of dust. The processing room where a depository film adheres: Since temperature is kept constant as the front face of 70 was described previously, between an adhesion film and a processing indoor wall surface, the force by expansion etc. does not occur and don't generate ablation of a film. By this example, generating of dust has been sharply reduced with the cure of this, and a counterelectrode and a stage electrode.

[0139] that by which this invention is limited to this although the above example explained focusing on etching and CVD -- it is not -- a plasma polymerization, a spatter, and ** -- if it is a process using plasma like, it is clear that it is applicable similarly

[0140] Although this example has explained the case where frequency is 68MHz and 100MHz, about the frequency of the RF generator for plasma generating, this is what was explained in the example about the conditions that the radiation effect of an electromagnetic wave is high, and the same effect will be acquired if high-frequency voltage is made higher than this on low frequency. Although not theoretically limited to frequency, the frequency on which the effect by experiment is checked at present is 10MHz or more. Although frequency higher than this was also theoretically usable, the discharge voltage in the need and capacity-coupling electric discharge became [the waveguide which a power supply cannot make easily at present] low, and since [-- electromagnetic radiation power cannot be done highly --] there was a problem in respect of being practical, this example did not explain.

[0141] Although this example explained magnetic field intensity centering on near the electron cyclotron resonance condition, in the result of an experiment, the effect that plasma density improves on no less than about 1/3 magnetic field conditions of electron cyclotron resonance conditions is seen. Although plasma density falls and there is a difference according to process conditions when plasma density increases to electronic cyclotron conditions with a magnetic field and the change of plasma density to magnetic field intensity strengthens magnetic field intensity further, it falls to the plasma density level of the conditions which do not impress a magnetic field by 3 times as many magnetic field intensity as this from the double precision of electron cyclotron resonance conditions. Therefore, although magnetic field intensity is not limited to electron cyclotron resonance conditions, an effect is large near the electron cyclotron resonance condition. It is shown that this phenomenon means that the energy supply to plasma from a ****** electromagnetic wave is controllable by the magnetic field for changing magnetic field intensity, and electronic energy control can perform it by the magnetic field.

[0142] this example explained the plasma generating method focusing on capacity-coupling electric discharge and the composite flash of electromagnetic radiation. Since it is the purpose to control an electronic energy state, this is explained focusing on this. however, the insulated conductor -- a member -- this very thing of generate [plasma] is also clear, and the method of making it the composition to which high-frequency voltage is impressed in between, and emitting an electromagnetic wave may become one plasma generating technology However, in order to prevent that high-frequency voltage

falls by the capacity-coupling component with plasma, the consideration which makes as small as possible capacity formed between an electrode and plasma is required of this method.
[0143] Processing room: About the temperature control of 70, by this example, although it was set as 50 degrees C, it is not limited to this. Since a depository film will no longer be formed in a front face, it will become impossible to form an always new depository side and temperature will also increase disassembly of an adhesion film rapidly above 200 degrees C if the temperature of an internal surface exceeds 200 degrees C, it is necessary to set it as the temperature not more than this. It is the temperature which 10 to 80 degrees C which sandwiched the temperature of the environment where equipment is used practical tend to use.
[0144]
[Effect of the Invention] In plasma treatment equipment, an electronic energy state can control now by this invention independently, and controls generating of active species by it by this, and it enabled it to aim at coexistence of the property that coexistence is difficult, with the conventional technology, such as high selective etching, high degree of accuracy and high-speed etching or membraneous quality, and membrane formation speed.
[0145] The density distribution of plasma can be controlled without changing hard composition, and a detailed pattern can be etched now with high precision all over the diameter substrate of macrostomia.
[0146] Generating of the dust accompanying plasma treatment and change of a plasma treatment property can be prevented, and the productivity of a semiconductor device and a liquid crystal display element can be raised now.
[0147] While being able to achieve highly efficient-ization of processings, such as a semiconductor device and a liquid crystal display element, and attaining production of a more highly efficient device by these, it is effective in the yield being good and being able to produce these devices for high productivity.

[Translation done.]